

- [54] **METHOD FOR MAKING TUBULAR POLYMERIC MEMBRANES FOR REVERSE OSMOSIS**
- [75] Inventors: **William Thayer; Lucien Pageau; Srinivasa Sourirajan**, all of Ottawa, Canada
- [73] Assignee: **Canadian Patents and Development Limited**, Ottawa, Canada
- [22] Filed: **May 29, 1973**
- [21] Appl. No.: **365,031**
- [30] **Foreign Application Priority Data**
Aug. 23, 1972 Canada 150045
- [52] **U.S. Cl.**..... **264/41; 210/500 M; 264/217; 264/269**
- [51] **Int. Cl.²**..... **B29D 27/04**
- [58] **Field of Search** **260/41, 45, 49; 264/41, 264/49, 45, 269, 212, 216, 217; 210/500 M**

[56] **References Cited**

UNITED STATES PATENTS

938,489	11/1909	James	264/269 X
2,293,365	8/1942	Scott	264/269 X
2,377,615	6/1945	Crane	264/269
3,387,348	6/1968	Kilgallon	264/269 X
3,446,359	4/1969	Loeb	210/490
3,544,358	12/1970	Manjikian	264/49 X
3,657,402	4/1972	Stana et al.	264/45
3,658,955	4/1972	Chamberlin et al.	264/45

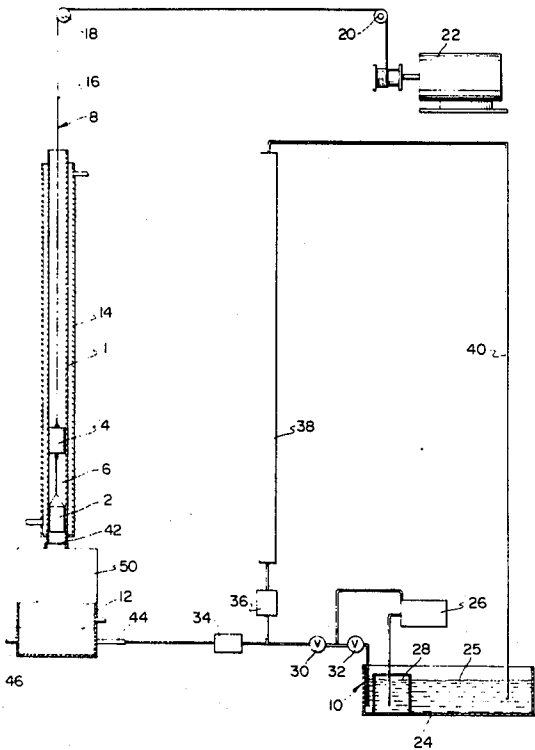
3,676,193 7/1972 Cooper 117/94

Primary Examiner—Philip Anderson
Attorney, Agent, or Firm—Francis W. Lemon

[57] **ABSTRACT**

Tubular polymeric membranes for reverse osmosis are produced by placing a casting bob in the one of a casting tube, pouring casting solution on the casting bob, attaching a leading bob on the casting bob to form a casting solution cavity over the casting bob, causing relative movement between the casting tube on one hand and the leading bob and casting bob on the other hand so that the position of the leading bob and casting bob in the casting tube is changed to adjacent the other end thereof and a tubular polymeric membrane is cast inside the casting tube, whilst the leading bob centers the casting bob in the casting tube, circulating a gelation medium inside the cast polymeric membrane, and then removing the cast polymeric membrane from the casting tube. Preferably fresh air is circulated along the inside surface of the tubular polymeric membrane as it is being cast. A cylindrical casing may be placed in sealing engagement on the casting bob and center the casting bob, and the casting solution poured in the casing, so that with the leading bob secured to the cylindrical casing, the cylindrical casing may be moved by a winch relative to the casting bob to release the casting solution as the casting bob is drawn along the casting tube.

4 Claims, 9 Drawing Figures



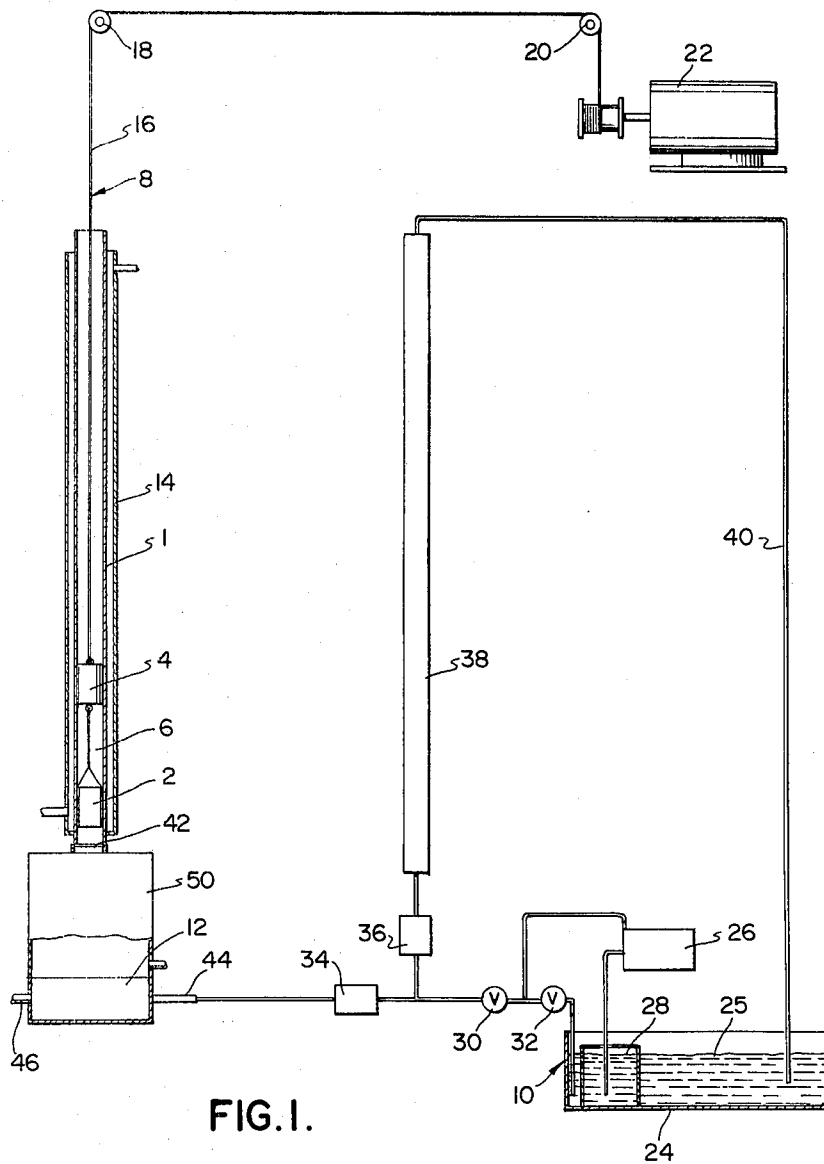


FIG. 2.

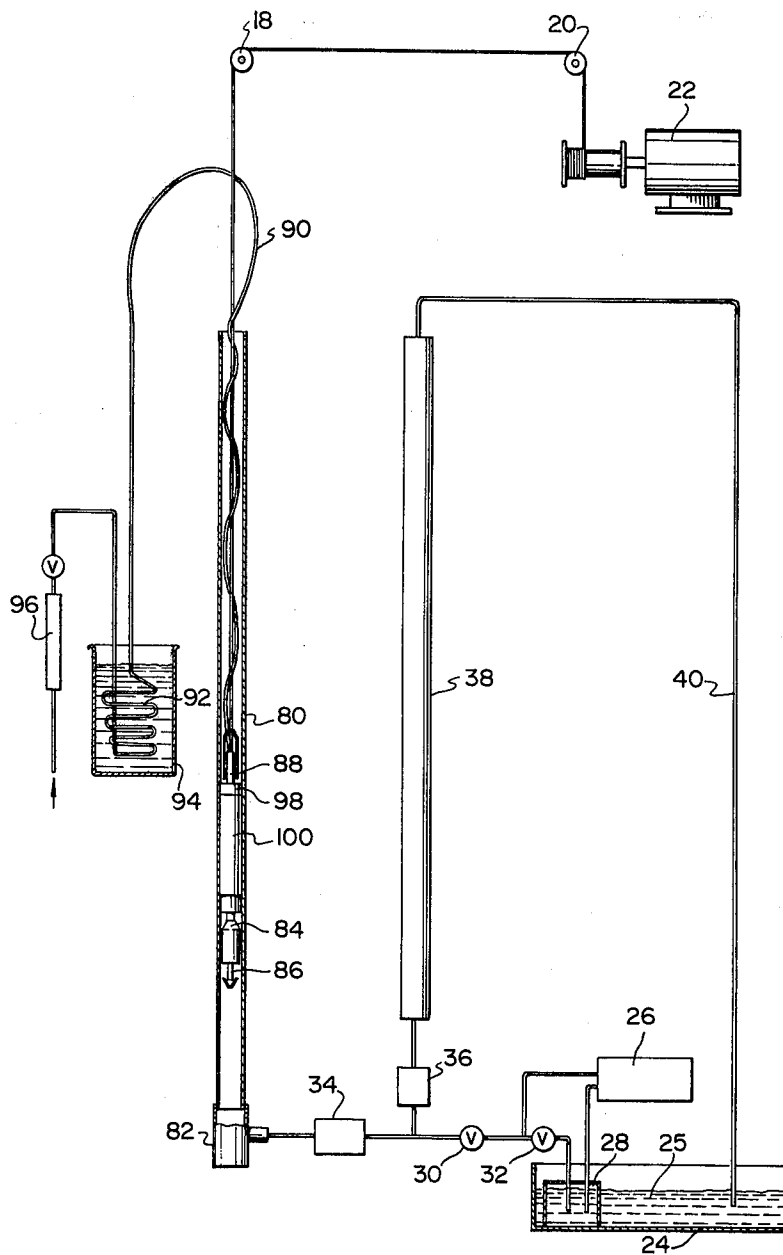
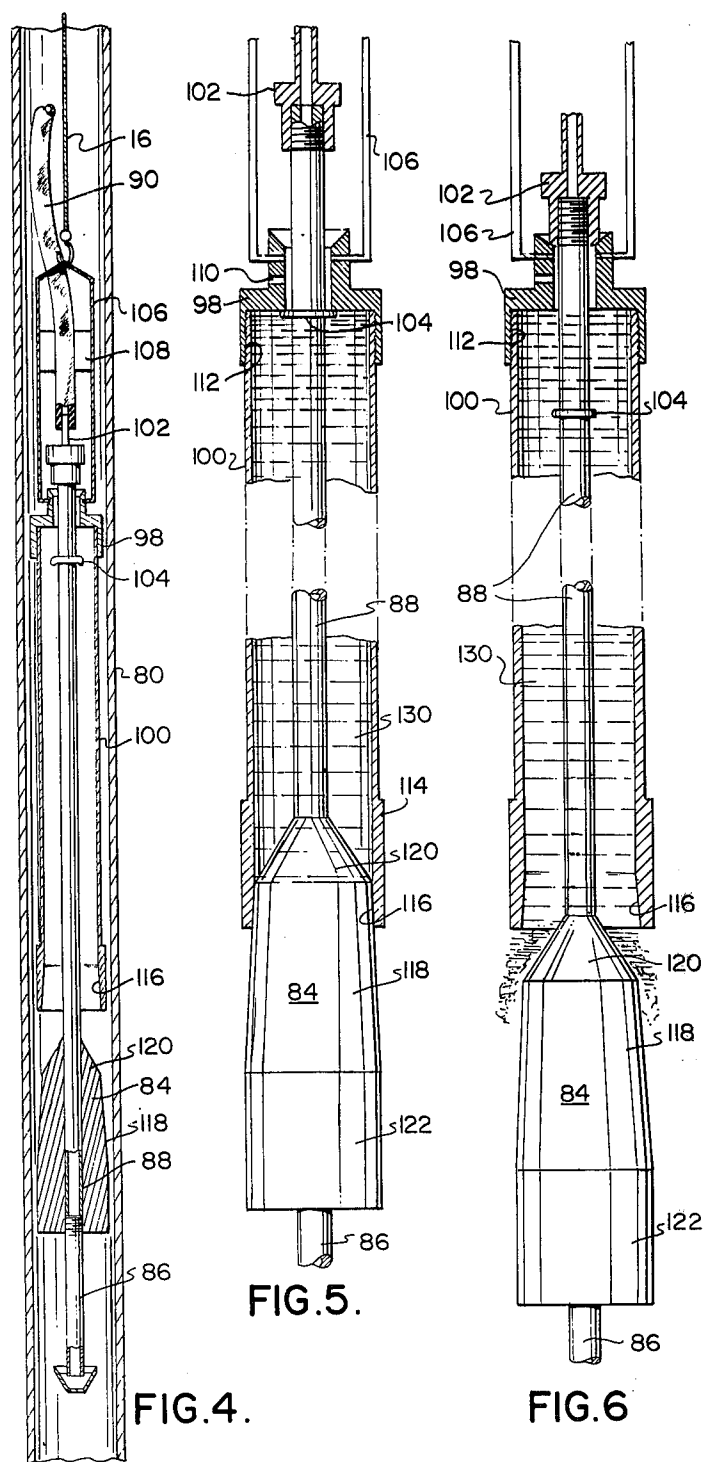


FIG.3.



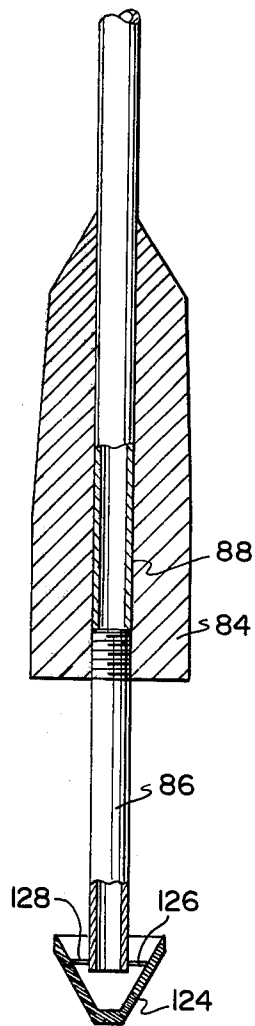


FIG. 7.

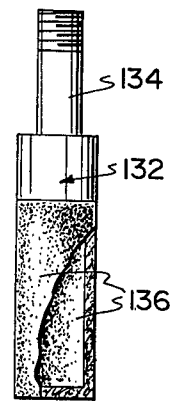


FIG. 8.

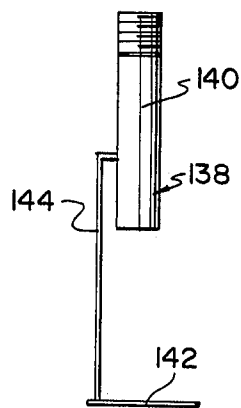


FIG. 9.

METHOD FOR MAKING TUBULAR POLYMERIC MEMBRANES FOR REVERSE OSMOSIS

This invention relates to a method for making a tubular polymeric membrane for reverse osmosis.

It has been shown by Kunst, B., and Sourirajan S., *J. of Applied Polymer Science* 14, 723, 1983 and 2559 (1970) that, in addition to casting solution composition, the temperature of film casting solution, temperature of the casting atmosphere, evaporation rate of the casting solution solvent, and period during film formation are important controlling parameters affecting the porous structure, and reverse osmosis performance of resulting polymeric membranes. Whilst the effects of such parameters have been studied, and superior polymeric membranes have resulted from such studies with respect to flat, polymeric membranes, no such studies have been carried out with respect to tubular, polymeric membranes because of the lack of suitable apparatus for making such polymeric membranes.

It is an object of the present invention to provide a method for making tubular, polymeric membranes for reverse osmosis, of different diameters, and under controlled conditions.

At the present time, tubular polymeric membranes of a cellulosic derivative are most popularly made by the gravity drop technique disclosed in U.S. Pat. No. 3,446,359, filed July 20, 1965, patented May 27, 1969, Inventors S. Loeb, S. Wasilewski, E. Selover and A. Balla, hereinafter referred to as the Loeb et al. process. In the Loeb et al. process the membrane is cast on the inside surface of a casting tube, in an annulus between the casting tube and a freely suspended casting bob. The casting bob is preferably fixed, and the casting tube is open ended and is moved downwardly by gravity to drop into an immersion tank containing ice cold water as a gelation medium for the cast membrane, and then the cast membrane is removed from the casting tube after gelation.

The Loeb et al. process, like all known other processes, is unsuitable for controlling the casting solution temperature, temperature of casting atmosphere, the evaporation rate of the casting solution solvent and period independantly during film formation on the casting tube, neither has it been used to study the effect of the film casting conditions on the performances for reverse osmosis of the resulting membranes. As a consequence, work on the development of polymeric membranes for reverse osmosis has been limited to the casting conditions obtainable in the particular apparatus used. For example, in the Loeb et al. process one end of the cast film has a longer solvent evaporation period than the other end, and so the evaporation time is not uniform throughout the length of the tubular membrane. Further, in practice, the solution temperature and the temperature of the casting atmosphere are always held at the temperature of the ambient atmosphere in using the Loeb et al. process.

It is a further object of the present invention to provide, in some embodiments, a method for making a tubular polymeric membranes for reverse osmosis, wherein:

- a. adequate control of the casting solution temperature is provided,
- b. adequate control of the temperature of the casting atmosphere is provided,

c. adequate control of the casting solution solvent evaporation rate and period independantly during film formation,

d. study is facilitated of the effect of the casting conditions outlines in (a) to (c) on the performance of resulting membranes.

Further objects of some embodiments of the present invention are to provide a method for making tubular polymeric membranes for reverse osmosis, wherein:

- a. the solvent evaporation time and rate for the cast tubular polymeric membrane is fairly uniform throughout its length,
- b. the casting solution temperature, and the temperature of the casting atmosphere may be held at a different temperature to that of the ambient atmosphere.

According to the present invention there is provided a method of manufacturing a tubular polymeric membrane for reverse osmosis, comprising:

- a. positioning at a lower end of a casting tube a casting bob,
- b. positioning a cylindrical casing on the casting bob,
- c. pouring a casting solution into the cylindrical casing, the casting solution comprising a polymer, a solvent with the polymer dissolved therein, and a pore producing agent for the polymer,
- d. attaching a leading bob to the casting bob to allow a clearance, when hauled, between the cylindrical casing and the casting bob,
- e. removably securing the cylindrical casing to the leading bob, and
- f. hauling the leading bob and the casting bob along the casting tube to initially cause the cylindrical casing to move away from the casting bob, whereby the casting solution is released from the cylindrical casing and a tubular polymeric membrane is cast, from the casting solution, between the casting tube and the casting bob, while the positions of the leading bob and the casting bob are being changed to positions adjacent the upper end of the casting tube,
- g. allowing solvent to evaporate from the cast tubular polymeric membrane,
- h. circulating through the casting tube a gelation medium for the cast tubular polymeric membrane, and then
- i. removing the cast tubular polymeric membrane from the casting tube.

Preferably a gas is circulated along the inside surface of the tubular polymeric membrane as it is being cast and/or after it is cast.

To provide an understanding generally of the method of preparing the tubular polymeric membranes or films, it may be pointed out at the outset that the film casting solution from which the films are cast contains usually a polymer, a solvent for the polymer and an additive which serves as a pore producing agent for the polymer. The polymer is usually cellulose acetate or other cellulose esters or cellulose derivatives. The solvent is usually acetone, or one or more of the numerous organic solvents capable of dissolving the polymer material used. The additive is usually formamide or aqueous solution of magnesium perchlorate or other perchlorates, or it can be any one or more of numerous water soluble inorganic or organic substances compatible with the solution of the polymer in the solvent.

Next film casting and subsequent solvent evaporation into air is accomplished most conveniently and effi-

ciently, but not essentially, at reduced temperatures to reduce the solvent evaporation rate and permit effective initiation of the desired organization of the water-cellulose acetate structure; then, after a predetermined time such that the solvent is not completely evaporated, the film is immersed in water, preferentially but not essentially ice water, to leach out the additive and complete the process of pore formation in the film.

In the accompanying drawings which illustrate by way of example, embodiments of the present invention:

FIG. 1 is a diagrammatic view of an apparatus developed by the Applicants prior to the present invention, for making a tubular polymeric membrane for reverse osmosis,

FIG. 2 is an enlarged, sectional side view of a base block assembly of FIG. 1,

FIG. 3 is a diagrammatic view of an apparatus according to the present invention that was developed from the apparatus shown in FIG. 1,

FIG. 4 is an enlarged sectional side view of a casting tube assembly of FIG. 3,

FIG. 5 is an enlarged view of a portion of FIG. 4, showing a cylindrical casing in sealed engagement with a casting bob,

FIG. 6 is a similar view to FIG. 5 but with the cylindrical casing raised from the casting bob,

FIG. 7 is a sectional side view of the casting bob of FIG. 3 showing details of an air disperser attached to it, and

FIG. 8 is a partly sectioned side view of a different air disperser to that shown in FIG. 7, and

FIG. 9 is a side view of yet another, different air disperser to that shown in FIG. 7.

Referring now to FIG. 1 there is shown an apparatus for making a tubular polymeric membrane for reverse osmosis, comprising:

- a. a casting tube 1,
- b. a casting bob 2 in one end of the casting tube 1 and slidable therealong for casting a tubular membrane (not shown) between the casting bob 2 and the casting tube 1,
- c. a vented leading bob 4 in the casting tube 1 and inwardly placed therein relative to the casting bob 2 with a casting solution cavity 6 between the leading bob 4 the casting bob 2 and the casting tube 1, the casting bob 2 being attached to the leading bob 4,
- d. a mounting means, generally designated by reference numeral 8, mounting the casting tube 1 and leading bob 4 and casting bob 2 for relative longitudinal movement between the casting tube 1 on the one hand and the leading bob 4 and the casting bob 2 on the other hand, whereby the position of the leading bob 4 and the casting bob 2 in the casting tube 1 are changed (as will be described later) to positions adjacent the other end of the casting tube 1, and
- e. means generally designated by the reference numeral 10, for circulating a gelation medium through the casting tube 1.

The casting tube 1 is mounted in a casting sleeve 42 in a base block 12, and has a water jacket 14 around it. The mounting means 8 is a winch assembly comprising a hawser 16, pulleys 18 and 20, and winch 22.

The means 10, for circulating a gelation liquid (in this instance is cold water) comprises a water bath 24 of ice cold water 25, a pump 26 for withdrawing ice cold water 25 from the bath 24 through a filter 28. Two

valves 30 and 32, valve 30 for regulating the flow of ice cold water from the pump 26 to the base block 12, and valve 32 for returning excess ice cold water from the pump 26 to the bath 24. Two solenoid operated valves 34 and 36 divide the flow of ice cold water from valve 30 to flow to the base block 12 and a calibrating tube 38, and the water from the calibrating tube 38 has a return flow connection 40 to the bath 24. The calibrating tube 38 has the same inside diameter as that of the casting tube 1.

Referring now to FIG. 2, as stated above the casting tube 1 is connected to the base block 12 by means of the casting sleeve 42. Casting sleeves 42, casting bobs 2, leading bobs 4 and casting tubes 1 of different sizes may be used with one base block 12, and so tubular polymeric membranes of different sizes may be cast using the same apparatus. The base block 12 has an ice cold water inlet 44 and a gas (in this embodiment air) inlet 46 both leading to a centering tube 48 which centers the casting bob 2 in the casting sleeve 42. A heat exchange casing 50 is provided on the base block 12 and extends around the casting sleeve 42.

The casting bob 2 has an upwardly extending connecting wire 52 attached to it. The connecting wire 52 extends through the casting solution cavity 6 between the casting bob 2 and the leading bob 4 and has a hook 54 at its upper end.

The leading bob 4 is vented by vent 56, and has a sponge wiper disc 58 secured to its lower end by a screw 60 and washer 62. The screw 60 has a stud-shaped end 64 for engagement with the hook 54. The hawser 16 is connected to the leading bob 4 by means of an eye bolt 66, and the casting tube 1 is a slide fit in a recessed portion 68 of the casting sleeve 42.

In operation the casting sleeve 42 is mounted in the base block 12 as shown in FIG. 2, and the casting bob 2 is placed in position on the centering tube 48, and then the required quantity of a casting solution 70 comprising 17% by weight of E-398-3 cellulose acetate (viscosity grade 3) obtainable from Eastman Organic Chemical Corp., Kingsport, Tennessee, U.S.A. acetone 69.2% by weight, 1.45% by weight magnesium perchlorate, water 12.35% by weight, and the casting solution temperature was held at 0°C. The use of the apparatus is not limited to the above casting solution. The casting solution is poured into the casting sleeve 42 on top of the casting bob 2. The open upper end of the casting sleeve 42 is closed by a removable plug (not shown) and the ice cold water inlet 44 and gas inlet 46 in the base block 12 are closed by means (not shown). The casing 50 is filled with ice cold water to form a heat absorbing mass. The base block 12 assembled with the casting bob 2, casting sleeve 42, and casting solution 70 is then placed in a thermostat box (not shown) held at 0° C to retard evaporation of the acetone from the casting solution 70.

In preparation for film casting, the speed of the winch 22 is set to the required speed for raising the casting bob 2 and leading bob 4 during casting, the temperature of the ice cold water 25 and the pumping rate of pump 26 are adjusted to that required for gelation of a cast tubular polymeric membrane in the casting tube 1. The base block 12 is then assembled as shown in FIG. 1, with the removable plug removed from the casting sleeve 42 and the leading bob 4 connected to the hook 54 by means of the stud-shaped end 64. During this period the water in the casing 50 tends to retard any change in temperature of the casting solution 70. The

water inlet 44 being opened to receive ice cold water 25 from tank 24 and the gas inlet 46 being opened and connected to a source (not shown) of compressed air. Water at the appropriate casting temperature is circulated through the water jacket 14.

The winch 22 is then started to raise the casting bob 2 and leading bob 4 up the casting tube 1. As the casting bob 2 moves up the casting tube 1 a tubular polymeric membrane is cast in an annular space between the casting tube 1 and casting bob 2, from casting solution flowing downwardly between the casting tube 1 and casting bob 2, from the casting solution 70. The vent 56 in the leading bob 4 allows air to enter the casting solution cavity 6 to replace the casting solution flowing downwardly. The sponge wiper disc 58 wipes the bore of the casting tube 14 and removes water therefrom as it travels up the casting tube 1.

When the casting bob 2 and leading bob 4 have reached their upper positions in the casting tube 1 the winch 22 is stopped, and the air supply to gas inlet 46 is continued for a sufficient period of time for solvent in the cast, tubular polymeric membrane to evaporate so that a skin is formed on the inner surface of the cast, polymeric membrane which is sufficiently strong to support the cast, polymeric membrane against it flowing down the casting tube 1. The air supply is then discontinued and the gas inlet pipe 46 is sealed.

Ice cold water 25 is then passed from the bath 24 to fill the cast, tubular polymeric membrane in the casting tube 1 for gelation and overflow the casting tube into the casing 50. The calibrating tube 38 is used to set the rate of liquid flow into the casting tube 14 and before casting so that the rate of flow of liquid into the casting tube 1 is equal to the predetermined rate of movement of the casting bob 2 along the casting tube 1 during casting, and to adjust from this the rate for gelation of the cast, tubular polymeric membrane.

The ice cold water is allowed to remain in the cast, tubular polymeric membrane in the casting tube 14 until the gelation process is complete, and then the ice cold water is drained therefrom back into the bath 24. The cast, tubular polymeric membrane thus gelled is then taken from the casting tube 1, after the casting tube 1 has been dismantled from the apparatus, and is ready for use in, for example, reverse osmosis experiments in the usual manner.

The apparatus shown in FIGS. 3 to 7 was developed from the apparatus shown in FIGS. 1 and 2 and similar parts in both apparatus are designated by the same reference numerals, and the previous description is relied upon to described them.

In FIG. 3 a casting tube 80, similar to the casting tube 1 (FIG. 1), is removably connected via connecting element 82 to the solenoid valve 34. The casting tube 80 may, if desired, be provided with a jacket (not shown) similar to jacket 14 (FIG. 1).

A casting bob 84 has an air disperser tube 86, depending therefrom from the lower end, and connected to a tube 88 passing through the casting bob 84. The tube 88 is connected by a flexible hose 90 to a heat exchange tube 92 of an air temperature control bath 94. The heat exchange tube 92 is connected via a gas flow meter 96 to a source of supply of pressurized air (not shown).

A leading bob 98 is above the casting bob 84. A cylindrical casing 100 is removably attached to, and extends downwardly from, the leading bob 98 to seal

with an upper end of the casting bob 84 before a casting operation.

Referring now to FIGS. 4 to 6 the tube 88 is shown passing through the casting bob 84 and connected to the flexible hose 90 by means of a removable connector 102 screwed on to the tube 88. The tube 88 has an O-ring seal 104 for sealing engagement with the leading bob 98. The hawser 16 is connected to the leading bob 98 by means of a press clip 106 and hook 107 on the lower end of the hawser 16, which is removable from the leading bob 98, has a support 108 welded to it for retaining the lower end of the flexible hose 90 in position.

The leading bob 98 has a vent 110 and is screwed on to a threaded end portion 112 of the cylindrical casing 100. The leading bob 98 is a slide fit in the casting tube 80 and centres an upper end of the cylindrical casing 100 in the casting tube 80. The cylindrical casing 100 has a lower, stepped end portion 114 which is a slide, locating fit in the casting tube 80 and centres a lower end of the cylindrical casing 100 in the casting tube 80.

The lower, stepped end portion 114 has a tapered bore 116 which corresponds to the taper of a tapered portion 118 of the casting bob 84. The casting bob 84 has a tapered upper portion 120 to direct casting solution downwardly and around the casting bob 84 to a cylindrical portion 112 which moulds the inner surface of cast polymeric tube as will be described later.

Referring now to FIG. 7 the air disperser tube 86 has an air disperser cap 124 secured to the lower, open end thereof by radially extending straps 126 and 128.

In operation the casting bob 84 with the tube 88 therein is held firmly in the vertical position away from the casting tube 80. At this stage the O-ring seal 104 and connector 102 are removed from the tube 88, and the air disperser tube 86 is removed from the casting bob 84. The cylindrical casing 100, with the leading bob 98 removed therefrom, is placed on the casting bob 84 so that the tapered bore 116 makes a metal-to-metal seal with the tapered portion 118 of the casting bob 84 as shown in FIG. 5. Casting solution designated 130 in FIGS. 5 and 6 is then poured into the casting bob 84 and the O-ring seal 104 is placed on the tube 88. The leading bob 98, with the press clip 106 removed therefrom, is then screwed on to the cylindrical casing 100 to press the O-ring seal 104 down in position as shown in FIG. 5. The casting solution 130 is now completely sealed in the cylindrical casing 100 by means of the casting bob 84 and the leading bob 98, O-ring seal 104 and tube 88. In contrast to when using the apparatus shown in FIGS. 1 and 2, the casting solution 130 thus sealed is easily handled by the exposed upper end of the tube 88, and may be stored vertically in a storage chamber at the required temperature for the casting solution 130.

In order to cast the solution the air disperser tube 86, with the air disperser cap 124 thereon, is screwed into the bottom end of the casting bob 84, and the assembly is held directly below the casting tube 80 which has been removed from the element 82. A supply of air is passed through the heat exchange tube 92 of the air temperature control bath and along the flexible hose 90. It will be appreciated that the air may be heated or cooled in the heat exchange tube 92 to the desired temperature, furthermore, a different gaseous atmosphere to air may be used if desired. The connector 102 is screwed on to the tube 88.

The flexible hose 90 is then passed through the support 108, and the press clip 106 with the flexible hose 90 attached to it is lowered down the casting tube 80 and out the lower end to a position above the leading bob 98. The flexible hose is connected to the connector 102 and the press clip 106 is connected to the leading bob 98. The assembly is then gently positioned in the lower end of the casting tube 80 by means of the winch 22.

The winch 22 is then started to raise the leading bob 98 at the desired casting speed. As the leading bob 98 is raised upwardly the cylindrical casing is raised upwardly away from the casting bob 84 until the leading bob 98 contacts the connector 102 as shown in FIG. 5. Thus the cylindrical casing 100 is no longer sealed to the casting solution and is able to flow downwardly around the casting bob 84. It should be noted that the connector 102 rests in a tapered recess in the leading bob 98 and is centered thereby to center the casting bob 84 in the casting tube 80.

Continued upward movement of the leading bob 98 draws the casting bob 84 up the casting tube 80 and casts a tubular polymeric membrane on the inside of the casting tube 80 in the manner previously described with reference to FIGS. 1 and 2.

As the tubular polymeric membrane is being freshly cast upwardly along the length of the casting tube 80 it is exposed to a stream of fresh air from the air disperser tube 86. The fresh air from the disperser tube 86 is deflected upwardly towards the freshly cast tubular polymeric membrane by the air disperser cap 124. The lower end of the casting tube 80 is not at this stage connected to the element 82 and so it is open to atmosphere to allow most of the solvent laden air, formed by evaporation of solvent from the cast tubular, polymeric membrane, to escape to atmosphere through the bottom of the casting tube 80.

When the leading bob 98 has reached the upper end of the casting tube 80 the winch 22 is stopped and the evaporation of solvent from the cast, polymeric membrane is allowed to continue for the period of time necessary to form the desired size and number of pores for the subsequent reverse osmosis process.

The element 82 is then connected to the lower end of the casting tube 80 and, as in the previous embodiment, ice cold water is pumped as a gelation medium into the casting tube 80 from the tank 24 by means of pump 26 at the same rate of movement as the casting bob 84 along the casting tube 80 during casting. The cast, tubular, polymeric membrane is allowed to set in the ice cold water and may then be removed quite easily by hand from the casting tube 80.

By using parts of the apparatus of different dimensions, different sizes of cast, tubular polymeric membrane may be made. In particular, by changing the length of the cylindrical casing 100 and that of the tube 88, cast, tubular polymeric membranes of any desired length, up to the length of the casting tube 80, can be made.

Several one-inch diameter by four feet long, tubular, cellulose acetate membranes have been successfully made using the apparatus shown in FIGS. 3 to 7. The casting solutions contained 17% by weight of E-398-3 cellulose acetate (viscosity grade 3) obtainable from Eastman Organic Chemical Corp., Kingsport, Tennessee U.S.A., acetone 69.2% by weight, 1.45% by weight magnesium perchlorate, water 12.35% by weight, and the casting solution temperature was held at 0°C, the

laboratory room temperature was the temperature of the casting atmosphere within the casting tube 80. The casting of polymeric membranes from this casting solution is a significant accomplishment because the applicants have been unable to find any indication in published literature that tubular polymeric membranes have ever been successfully cast from such casting solutions. Using this casting solution the leading bob 98 and the casting bob 84 were hauled along the tube at casting speeds within the range 0.05 to 10.0 cm/second to form the cast, polymeric membrane. The evaporation period for the cast polymeric membrane before gelation was determined experimentally and ranged from thirty seconds to four minutes, preferably in this instance one to two minutes. However, the desired evaporation period was found to be dependant upon a number of factors such as casting speed, casting temperature and volume of air circulated along the surface of the cast polymeric membrane.

Several samples of these cast, tubular polymeric membranes were cut from the bottom, middle, and top of the lengths cast in the casting tube 80, and were tested flat in reverse osmosis experiments at 250 psig. using aqueous feed solutions containing 3500 ppm of sodium chloride. The results tabulated below were typical of those obtained with many samples of membranes tested:

Membrane shrinkage temperature		Performance of membranes from		
		Bottom	Middle	Top
Unshrunk	% sepn.	40.1	40.1	39.9
	Flux *	62.8	62.9	62.9
65°C	% sepn.	85.4	85.9	86.1
	Flux *	21.3	20.2	20.8
70°C	%sepn.	90.7	91.7	91.6
	Flux *	16.6	16.4	16.4
75°C	%sepn.	95.4	95.7	96.0
	Flux *	10.8	9.6	9.6

* Flux in gallons/day. sq. ft.

The above test results testify to the uniformity of the membranes obtainable by apparatus according to the present invention.

It will be appreciated that it is within the scope of the present invention to move the casting tube 80 downwardly during casting with the leading bob 98, cylindrical casing 100, and casting bob 84 all either stationary or moved upwardly. However, with the casting tube 80 held stationary as described, and the leading bob 98 hauled upwardly by means of the winch 22 at a controlled speed, the use of a leading bob 98 to form a casting solution cavity and the delivery of fresh air or other gas at a controlled rate and temperature through an air disperser 124 on the freshly cast tubular, polymeric membrane, facilitate the following being controlled independently of one another: the temperature of the casting solution, the temperature of the casting surface, speed of film casting, and solvent evaporation from the cast tubular, polymeric membrane.

In FIG. 8 there is shown a different air disperser 132 which may be used with the casting bob 84 (FIGS. 3 to 7). The air disperser 132 comprises a threaded tube 134, for screwing into the casting bob 84, and a porous tube 136. The porous tube 136 traps any dust particles in the air.

In FIG. 9 there is shown yet another, different air disperser 138 that may be used with the casting bob 84 (FIGS. 3 to 7). The air disperser 138 comprises a

threaded tube 140 for screwing into the casting bob 84, and a circular air deflection disc 142 joined to the tube 140 by a bracket 144. The air issuing from the tube 140 is deflected towards the cast, tubular polymeric membrane by the air deflection disc 142.

It will be appreciated that the position of the air disperser from the bottom of the casting bob influences the evaporation rate of solvent from the cast, tubular polymeric membrane.

Thus with reference to FIG. 7, the length of the tube 86 will have an effect on the rate of solvent evaporation. In FIG. 8 the length of tube 134 will have an effect on the rate of solvent evaporation.

With reference to FIG. 9 the length of bracket 144 will affect the rate of evaporation and may be made adjustable.

If desired a tube extending along the bore of tube 140 may deliver the air for deflection by the air deflection disc, and tube 140 may be used as a return tube for conveying solvent laden air away from inside the cast, tubular polymeric membrane.

We claim:

1. A method of manufacturing a tubular polymeric membrane for reverse osmosis, comprising:

- a. positioning a cylindrical casing on a casting bob,
- b. pouring a casting solution into the cylindrical casing, the casting solution comprising a polymer, a solvent with the polymer dissolved therein, and a pore producing agent for the polymer,
- c. attaching a leading bob to the casting bob to allow a clearance, when hauled, between the cylindrical casing and the casting bob,
- d. removably securing the cylindrical casing to the leading bob, and

e. positioning at a lower end of a casting tube the casting bob with the cylindrical casing positioned thereon, containing the casting solution, and the leading bob attached thereto and removably secured to the cylindrical casing,

f. causing relative movement between the casting tube and the leading bob to initially cause the cylindrical casing to move away from the casting bob, whereby the casting solution is released from the cylindrical casing, and then a tubular polymeric membrane is cast, from the released casting solution, between the casting tube and the casting bob, while the positions of the leading bob and the casting bob are being changed to positions adjacent the upper end of the casting tube,

g. allowing solvent to evaporate from the cast tubular polymeric membrane,

h. circulating through the casting tube a gelation medium for the cast tubular polymeric membrane, and then

i. removing the cast tubular polymeric membrane from the casting tube.

2. A method according to claim 1, wherein the rate of evaporation of solvent from the cast tubular polymeric membrane is controlled by circulating a gas along the inside surface of the tubular polymeric membrane.

3. A method according to claim 2, wherein the gas is circulated along the inside surface of the tubular polymeric membrane as the tubular polymeric membrane is being cast.

4. A method according to claim 3, wherein the gas is directed towards freshly cast tubular polymeric membrane.

* * * * *